# PATENT ABSTRACTS OF JAPAN

(11)Publication number : 07-320188
(43)Date of publication of application : 08.12.1995

(51)Int.Cl. G08G 1/01
B62D 6/00
// B62D137:00

(21)Application number : 06-110882
(22)Date of filing : 25.05.1994

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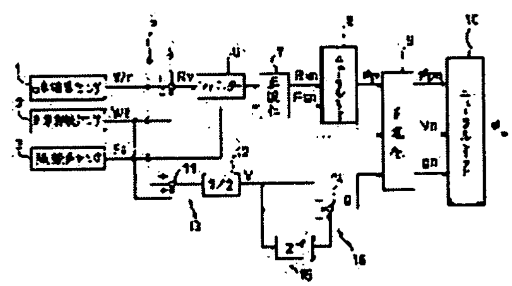
## (54) METHOD AND DEVICE FOR ESTIMATING YAW RATE OF VEHICLE

(57)Abstract:
PURPOSE: To reduce the burden on a computer by not only improving the estimation precision but also reducing the number of neurons in an intermadiate layer at the time of estimating a yaw rate by neural network operation.




CONSTITUTION: A rotation difference RV between right and left wheels, steering angle Fs, vehicle velocity V, and vehicle body acceleration (g) are detected by detecting means 5, 3, 13, and 16, respectively. After the rotation difference Rv between right and left wheels and the steering angle Fs are normalized, an approximate yaw rate value ϕp is calculated by a first neural network operation part 8 which takes these normalized values Rvn and Fsn as input variables. After the approximate yaw rate value ϕp, the vehicle velocity V, and the vehicle body acceleration (g) are normalized, an estimated yaw rate value ϕ is calculated by a second neural network operation part 10 which takes these normalized values ϕpn, Vn, and gn as input variables.

LEGAL STATUS

[Date of request for examination]

[Date of sending the examiner's decision of rejection]

[Kind of final disposal of application other than the examiner's decision of rejection or application converted registration]

[Date of final disposal for application]

[Patent number]

[Date of registration]

[Number of appeal against examiner's decision of rejection]

[Date of requesting appeal against examiner's decision of rejection]

[Date of extinction of right]

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## DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[Industrial Application] This invention relates to the yaw rate presumption approach of presuming the yaw rate generated on a car, and its equipment.
[0002]
[Description of the Prior Art] Conventionally, when equipping a four-flower power steering system in a car, a sensor detects the yaw rate generated on a car, and carrying out feedback control using this yaw rate is known. There are what detects a yaw rate by the linearity formula drawn based on the rotation difference of a right-and-left ring from the geometric relation at the time of circle revolution (the so-called two-flower model) (for example, refer to JP,2-40504,A), and a thing (for example, refer to JP,4-353076,A) which detects a yaw rate by the linearity formula drawn from the geometric relation at the time of circle revolution based on the steering angle in the conventional yaw rate sensor.
[0003] However, since each above-mentioned conventional yaw rate sensor was what detects a yaw rate by the linearity formula drawn from the geometric relation at the time of circle revolution, when it was beyond a predetermined value in the movement condition of a nonlinear field, i.e., a right-and-left ring rotation difference, or when a tire handling angle was beyond a predetermined value, it had a problem of it become impossible to detect a yaw rate with a sufficient precision.
[0004] Then, in order to presume a yaw rate with a sufficient precision in the movement condition of a nonlinear field in recent years, what used the neural network is proposed. While usually doing synaptic connection to an interlayer's neurone by making car quantity of states, such as a rotation difference of the right-and-left ring relevant to a yaw rate, a steering angle, a steering rate, the vehicle speed, and car-body acceleration, into an input variable, this neural network It is proved that synaptic connection of this interlayer's neurone is carried out to the neurone of the output layer which outputs a presumed yaw rate value, it is constituted, a nonlinear field is covered from a linearity field by raising the count of study, and a yaw rate can be presumed in a high precision.
[0005]
[Problem(s) to be Solved by the Invention] However, in order to presume a yaw rate with a sufficient precision by the above-mentioned neural network, it is necessary to make [ many ] the degree of an input variable, and an interlayer's neurone, therefore a neural

network operation takes time amount, and there is a problem that the burden of the computer which performs this operation becomes large.

[0006] This invention is made in view of this point, and the place made into the purpose lessens an interlayer's number of neurone, and enables it to mitigate the burden of a computer, changing a neural network's configuration and raising the presumed precision of a yaw rate.

[0007]

[Means for Solving the Problem] In order to attain the above-mentioned purpose, invention according to claim 1 As the yaw rate presumption approach of presuming the yaw rate generated on a car, the rotation difference of a right-and-left ring, Detect a steering angle and other one or more car quantity of states, respectively, and an approximation yaw rate value is computed by the neural network operation which makes an input variable the rotation difference and steering angle of the above-mentioned right-and-left ring. Furthermore, it considers as the configuration which computes a presumed yaw rate value by the neural network operation which makes an input variable this approximation yaw rate value and the above and other one or more car quantity of states.

[0008] Invention according to claim 2 is subordinate to invention according to claim 1, and shows one mode the above and other one or more car quantity of states are [ mode ] with the vehicle speed and car-body acceleration.

[0009] Invention according to claim 3 as the yaw rate presumption approach of presuming the yaw rate generated on a car While computing an approximation yaw rate value by the neural network operation which detects the rotation difference of a right-and-left ring, a steering angle, and other one or more car quantity of states, respectively, and makes an input variable the rotation difference and steering angle of the above-mentioned right-and-left ring The correction factor which is the function value is calculated from the above and other one or more car quantity of states, and it considers as the configuration which computes a presumed yaw rate value by multiplying by this correction factor with the above-mentioned approximation yaw rate value.

[0010] Invention according to claim 4 is subordinate to invention according to claim 3, and shows the one mode. That is, the above and other one or more car quantity of states are with the vehicle speed and car-body acceleration, and the above-mentioned correction factor is considered as the configuration to which the vehicle speed or car-body acceleration becomes large and which is set up so that it may follow and may become small linearly.

[0011] Invention according to claim 5 as the yaw rate presumption approach of presuming the yaw rate generated on a car While computing an approximation yaw rate value by the linearity formula which detected the rotation difference of a right-and-left ring, a steering angle, and other one or more car quantity of states, respectively, and was drawn from the geometric relation at the time of circle revolution based on either the rotation difference of the above-mentioned right-and-left ring, and the steering angle It considers as the configuration which computes an error value by the neural network operation which makes an input variable another side of the rotation difference of the above-mentioned right-and-left ring, and a steering angle, and the above and other one or more car quantity of states, and computes a presumed yaw rate value by adding this error value to the above-mentioned approximation yaw rate value.

[0012] Here, the linearity type of the yaw rate phi drawn from the geometric relation at the time of circle revolution based on the rotation difference of a right-and-left ring is

phi=Rv when Rv and a tread are set to d for a right-and-left ring rotation difference. /d -- It is **. Moreover, the linearity type of the yaw rate phi drawn from the geometric relation at the time of circle revolution based on the steering angle is phi={V/(1+axV2)} xFs/L, when V and a wheel base are set to L and it sets [ a steering angle ] a stability factor to a for Fs and the vehicle speed. -- It is **.

[0013] Invention according to claim 6 shows one mode of invention according to claim 5. Namely, while computing an approximation yaw rate value by the linearity formula which detected the rotation difference, the steering angle, the steering rate, the vehicle speed, and car-body acceleration of a right-and-left ring, respectively, and was drawn from the geometric relation at the time of circle revolution based on the rotation difference of the above-mentioned right-and-left ring An error value is computed by the neural network operation which makes an input variable the above-mentioned steering angle, a steering rate, and the vehicle speed. A presumed yaw rate value is computed by adding this error value to the above-mentioned approximation yaw rate value, and it asks for the correction factor which is the function value from the above-mentioned car-body acceleration further, and considers as the configuration which multiplies by this correction factor with the above-mentioned presumed yaw rate value, and amends a presumed yaw rate value.

[0014] Invention according to claim 7 as yaw rate presumption equipment which presumes the yaw rate generated on a car A detection means to detect the rotation difference of a right-and-left ring, a steering angle, and other one or more car quantity of states, respectively, The approximation yaw rate value operation part which computes an approximation yaw rate value by the neural network operation which makes an input variable the rotation difference and steering angle of the above-mentioned right-and-left ring, Furthermore, it considers as a configuration equipped with the presumed yaw rate value operation part which computes a presumed yaw rate value by the neural network operation which makes an input variable this approximation yaw rate value and the above and other one or more car quantity of states.

[0015] Invention according to claim 8 as yaw rate presumption equipment which presumes the yaw rate generated on a car A detection means to detect the rotation difference of a right-and-left ring, a steering angle, and other one or more car quantity of states, respectively, The approximation yaw rate value operation part which computes an approximation yaw rate value by the neural network operation which makes an input variable the rotation difference and steering angle of the above-mentioned right-and-left ring, It considers as a configuration equipped with the correction factor operation part which calculates the correction factor which is the function value from the above and other one or more car quantity of states, and the presumed yaw rate value operation part which computes a presumed yaw rate value by multiplying by this correction factor with the above-mentioned approximation yaw rate value.

[0016] Invention according to claim 9 as yaw rate presumption equipment which presumes the yaw rate generated on a car A detection means to detect the rotation difference of a right-and-left ring, a steering angle, and other one or more car quantity of states, respectively, The approximation yaw rate value operation part which computes an approximation yaw rate value by the linearity formula drawn from the geometric relation at the time of circle revolution based on either the rotation difference of the above-mentioned right-and-left ring, and the steering angle, The error value operation part which computes an error value by the neural network operation which makes an input variable

another side of the rotation difference of the above-mentioned right-and-left ring, and a steering angle, and the above and other one or more car quantity of states, It considers as a configuration equipped with the presumed yaw rate value operation part which computes a presumed yaw rate value by adding this error value to the above-mentioned approximation yaw rate value.

[0017]

[Function] By the above-mentioned configuration, in invention according to claim 1, 2, or 7 An approximation yaw rate value is computed by the neural network operation which makes an input variable the rotation difference and steering angle of a right-and-left ring. Since the presumed yaw rate value is computed by the neural network operation which makes an input variable this approximation yaw rate value and other car quantity of states, such as the vehicle speed and car-body acceleration, An interlayer's number of neurone combined with the degree of input and these in each neural network decreases, and the time amount which the whole neural network operation takes also decreases. Moreover, as an input variable, since other car quantity of states, such as the vehicle speed and car-body acceleration, are also used in addition to the rotation difference of a right-and-left ring, and the steering angle, a yaw rate is presumed with a sufficient precision.

[0018] While a related degree with a yaw rate computes an approximation yaw rate value in invention according to claim 3, 4, or 8 by the neural network operation which makes an input variable the rotation difference and steering angle of a large right-and-left ring Since the presumed yaw rate value is computed by calculating the correction factor which is the function value from other car quantity of states, such as the vehicle speed and car-body acceleration, and multiplying by this correction factor with the above-mentioned approximation yaw rate value, An interlayer's number of neurone combined with the degree of input and these in a neural network decreases, and the time amount which a neural network operation takes decreases. Moreover, the presumed precision of a yaw rate is raised by the amendment using the vehicle speed, car-body acceleration, etc.

[0019] In invention according to claim 5 or 9, while computing an approximation yaw rate value by the linearity formula drawn from the geometric relation at the time of circle revolution based on either the rotation difference of a right-and-left ring, and the steering angle An error value is computed by the neural network operation which makes an input variable another side of the rotation difference of the above-mentioned right-and-left ring, and a steering angle, and other car quantity of states, such as the vehicle speed and car-body acceleration. Since the presumed yaw rate value is computed by adding this error value to the above-mentioned approximation yaw rate value, an interlayer's number of neurone combined with the degree of input and these in a neural network decreases, and the time amount which a neural network operation takes decreases. Moreover, the presumed precision of a yaw rate is raised by adding and amending the error value by the neural network operation to the approximation yaw rate value computed by the linearity formula drawn from the geometric relation at the time of circle revolution.

[0020] In invention according to claim 6, while computing an approximation yaw rate value by the linearity formula drawn from the geometric relation at the time of circle revolution based on the rotation difference of a right-and-left ring An error value is computed by the neural network operation which makes an input variable a steering angle, a steering rate, and the vehicle speed. Since computed the presumed yaw rate value by having added this error value to the above-mentioned approximation yaw rate value, it

asked for the correction factor which is the function value from car-body acceleration further, it multiplied by this correction factor with the above-mentioned presumed yaw rate value and the presumed yaw rate value is amended, the presumed precision of a yaw rate is raised more.

[0021]

[Example] Hereafter, the example of this invention is explained based on a drawing.

[0022] Drawing 1 is the block diagram of the yaw rate presumption equipment of the car concerning the 1st example of this invention. In drawing 1 , the right wheel speed sensor which detects the wheel speed whose 1 is a rotational frequency per predetermined time of a right wheel, the left wheel speed sensor by which 2 detects the wheel speed of a left wheel, and 3 are the steering angle sensors as a steering angle detection means to detect the steering angle of the front wheel which is a steering wheel. The wheel speed Wr detected by both the above-mentioned wheel speed sensors 1 and 2, and Wl It is the rotation difference (in detail the rotational frequency difference thru/or rotational-speed difference per predetermined time) Rv of a right-and-left ring by subtracting mutually in a summation point 4. A rotation difference detection means 5 by which it is computed and the wheel speed sensors 1 and 2 and a summation point 4 detect the rotation difference of a right-and-left ring is constituted. The above-mentioned rotation difference Rv It is inputted into the approximation yaw rate value operation part 8 through a filter 6 and the normalization processing section 7. Moreover, steering angle Fs detected by the above-mentioned steering angle sensor 3 It is inputted into the approximation yaw rate value operation part 8 through the normalization processing section 7.

[0023] The above-mentioned approximation yaw rate value operation part 8 is approximation yaw rate value phip by the neural network operation to which it is constituted by the neural network who makes an input variable the rotation difference normalizing value Rvn and the steering angle normalizing value Fsn of a right-and-left ring which were respectively normalized in the normalization processing section 7, and has the neurone of plurality (they are six pieces in the case of this example) in an interlayer, and this neural network considers the rotation difference normalizing value Rvn and the steering angle normalizing value Fsn of a right-and-left ring as an input variable. It computes. This approximation yaw rate value phip It is inputted into the presumed yaw rate value operation part 10 through the normalization processing section 9.

[0024] Moreover, the wheel speed Wr detected by both the above-mentioned wheel speed sensors 1 and 2 and Wl While being mutually added in a summation point 11, a vehicle speed detection means 13 by which the vehicle speed V is computed and the wheel speed sensors 1 and 2, a summation point 11, and the multiplier addition section 12 detect the vehicle speed V is constituted by doubling this aggregate value 1/2 in the multiplier addition section 12. The vehicle speed V is inputted into the presumed yaw rate value operation part 10 through the normalization processing section 9. Moreover, an acceleration detection means 16 by which the car-body acceleration g is computed and a summation point 14 and a delay circuit 15 detect the car-body acceleration g by being inputted after 1 measurement timing ****** in a delay circuit 15, and subtracting both this input value mutually in this summation point 14 in addition to the above-mentioned vehicle speed detection means 13 while the vehicle speed V is inputted as it is to a summation point 14 is constituted. The above-mentioned car-body acceleration g is inputted into the presumed yaw rate value operation part 10 through the normalization

processing section 9.

[0025] The above-mentioned presumed yaw rate value operation part 10 Approximation yaw rate value normalizing-value phipn and the vehicle speed normalizing value Vn which were respectively normalized in the normalization processing section 9 Car-body acceleration normalizing value gn It is constituted by the neural network who considers as an input variable and has the neurone of plurality (they are six pieces in the case of this example) in an interlayer. This neural network is approximation yaw rate value normalizing-value phipn and the vehicle speed normalizing value Vn. Car-body acceleration normalizing value gn The presumed yaw rate value phi is computed by the neural network operation made into an input variable. This presumed yaw rate value phi is the output signal of yaw rate presumption equipment.

[0026] Next, in the yaw rate presumption equipment of the 1st example of the above, the yaw rate presumption approach which is the operations sequence in the case of presuming a yaw rate is explained according to the Maine flow chart shown in drawing 2 .

[0027] It sets to drawing 2 and is step S1 first. Step S2 after waiting to become measurement timing Right wheel speed Wr as car movement information And left wheel speed Wl While measuring by the wheel speed sensors 1 and 2, respectively, it is step S3. Steering angle Fs as driver actuation information It measures by the steering angle sensor 3. Then, step S4 It sets and is the above-mentioned right wheel speed Wr. Left wheel speed Wl Right-and-left ring rotation difference Rv which is difference While asking in a summation point 4, it is this right-and-left ring rotation difference Rv. It receives and filter count is carried out with a filter 6. This right-and-left ring rotation difference Rv Filter count is the following formula. Rvf=Filter (Wl-Wr)
= b (1) -Rv(t)+b (2) -Rv(t-1) +b (3) -Rv (t-3) + b (4) -Rv(t-4) +b (5) -Rv(t-5)-a (2) -Rvf (t-1) - a (3) -Rvf (t-2)-a (4) -Rvf (t-4)-a (5) -Rvf (t-5) -- ** performs. However, a filter constant is a= [1.0-2.5562 2.6311-1.2487 0.2299].
b=[0.0199 -0.0052 0.0266 -0.0052 0.0199]
It comes out.

[0028] After the above-mentioned filter count and step S5 Right-and-left ring rotation difference Rv which is the input (first stage input) in the normalization processing section 7 And steering angle Fs It normalizes. This normalization count is the following formula Rvn=Rv / 2 Fsn=Fs / 5P=[ 1 ] [Rvn, Fsn] t. -- ** performs.

[0029] Then, step S6 The neural network operation which makes an input variable the right-and-left ring rotation difference normalizing value Rvn and the steering angle normalizing value Fsn by the approximation yaw rate value operation part 8 is carried out, and it is approximation yaw rate value phip. It computes. This approximation yaw rate value phip Count (count of a first stage neural network) is performed according to the flow chart shown in drawing 3 .

[0030] Then, step S7 Approximation yaw rate value phip which is the input (second stage input), the vehicle speed V, and the car-body acceleration g are normalized in the normalization processing section 9. This normalization is preceded and they are the wheel speed Wr of a right-and-left ring, and Wl with the vehicle speed detection means 13. While being based and detecting the vehicle speed V, the acceleration detection means 16 detects the differential value empty vehicle object acceleration g of this vehicle speed V. moreover, normalization count -- following formula phi pn=phi p/30gn -- ={V(t)-V (t-1)} / 10Vn = (V-70) / 70P2 =[-- phi -- pn, gn, and Vn]t --** performs.

[0031] Then, step S8 They are approximation yaw rate value normalizing-value phipn

and the vehicle speed normalizing value Vn at the presumed yaw rate value operation part 10. Car-body acceleration normalizing value gn The presumed yaw rate value phi is computed by carrying out the neural network operation made into an input variable. Count (count of a second stage neural network) of this presumed yaw rate value phi is performed according to the flow chart shown in drawing 4 . After an appropriate time and step S9 The presumed yaw rate value phi is outputted and it is step S1. It returns.

[0032] Next, count of a first stage neural network is explained according to the flow chart shown in drawing 3 .

[0033] After first inputting the normalization information P1 (the right-and-left ring rotation difference normalizing value Rvn and steering angle normalizing value Fsn) at step S11 in drawing 3 , It is the matrix product U0 of this normalization information P1 and the interlayer weighting factor W1 (i, j) at step S12. It asks and is this matrix U0 at step S13. Interlayer bias coefficient B 1 (i) is added and it is newly a matrix U0 about that value. It replaces. Here, i is an interlayer's number of neurone, j is the number of inputs, and, in the case of this example, it is i= 6 and j= 2.

[0034] Then, it is the above-mentioned matrix U0 at step S14. The interlayer transfer function U (=tanh (U0)) which is a tangent hyperbolic function is calculated. Having used the tangent hyperbolic function for the interlayer transfer function responds to an input being distributed over both positive/negative. Count of this middle class transfer function U is performed according to the flow chart shown in drawing 5 . They are the above-mentioned interlayer transfer function U and the output layer weighting factor W2 at after an appropriate time and step S15. Approximation yaw rate value phip which is a matrix product with (i) It asks and is this approximation yaw rate value phip at step S16. Output layer bias multiplier B-2 It adds and is newly approximation yaw rate value phip about that value. It replaces. It returns to the Maine flow chart after that.

[0035] In addition, the middle class weighting factor W1, the middle class bias coefficient B 1, and the output layer weighting factor W2 And output layer bias multiplier B-2 It is determined [ all / equipment ] before manufacture of the yaw rate presumption equipment concerning this example by the study using a back-propagation method as well as them of the count of a first stage neural network mentioned later.

[0036] Next, count of a second stage neural network is explained according to the flow chart shown in drawing 4 .

[0037] After first inputting the normalization information P2 (presumed yaw rate value normalizing-value phipn, the car-body acceleration normalizing value gn, and vehicle speed normalizing value Vn) at step S21 in drawing 4 , It is this normalization information P2 at step S22. Matrix product U0 with the interlayer weighting factor W1 (i, j) It asks and is this matrix U0 at step S23. The interlayer bias coefficient B 1 (i) is added, and it is newly a matrix U0 about that value. It replaces. In the case of this example, it is i= 6 and j= 3.

[0038] Then, it is the above-mentioned matrix U0 at step S24. The interlayer transfer function U (=tanh (U0)) which is a tangent hyperbolic function is calculated. Count of this middle class transfer function U is performed according to the flow chart shown in drawing 5 . They are the above-mentioned interlayer transfer function U and the output layer weighting factor W2 at after an appropriate time and step S25. The presumed yaw rate value phi which is a matrix product with (i) is calculated, and it is output layer bias multiplier B-2 to this presumed yaw rate value phi at step S16. It adds and that value is newly replaced with the presumed yaw rate value phi. It returns to the Maine flow chart

after that.
[0039] Next, count of the middle class transfer function U is explained according to the flow chart shown in drawing 5 .
[0040] It is the value U0 of a matrix at the step S32 after setting 1 to Variable ii at step S31 first in drawing 5 . It judges whether (ii) is forward or it is negative. When it is forward, while resetting Flag f by SUTEBBU S33 and shifting to step S36, when it is negative, Flag f is set at step S34, and it is the value U0 of a matrix at step S35. After hanging a minus sign on (ii) and transposing to a forward value, it shifts to step S36. At step S36, interlayer transfer function value U (ii) corresponding to the above-mentioned value U0 (ii) is computed using the map created beforehand. The above-mentioned map expresses U=tanh (U0) in 0 <=U0 <=20. Thus, computation time can be saved if interlayer transfer function value U (ii) is computed using a map.
[0041] When judging and setting whether Flag f is set at step S37 after an appropriate time that is, it is the value U0 of a matrix previously. While making (ii) into the forward value, a minus sign is hung on this value at step S38, and it returns to the original negative value. Then, after counting up Variable ii one time at step S39, it judges whether Variable ii is larger than the degree i of a neural network's input at step S40. When this judgment is NO, while returning to step S32, when a judgment is YES, the interlayer transfer function U is ended, and it returns to neural network count.
[0042] As mentioned above, it is approximation yaw rate value phip by the neural network operation which makes an input variable the right-and-left ring rotation difference normalizing value Rvn and the steering angle normalizing value Fsn in the 1st example. It computes. Normalizing-value phip of this approximation yaw rate value Vehicle speed normalizing value Vn Car-body acceleration normalizing value gn Since the presumed yaw rate value phi is computed by the neural network operation made into an input variable, The above-mentioned right-and-left ring rotation difference normalizing value Rvn, the steering angle normalizing value Fsn, and vehicle speed normalizing value Vn Car-body acceleration normalizing value gn It compares, when computing the presumed yaw rate value phi by the neural network operation made into an input variable. An interlayer's number of neurone combined with the degree of input and these in each neural networks 8 and 10 can be lessened. Consequently, time amount which the whole neural network operation takes can be lessened, and the burden of the computer which performs this operation can be mitigated. Moreover, since the degree of input itself does not decrease, presumed precision of a yaw rate can be made good.
[0043] Drawing 6 is the block diagram of the yaw rate presumption equipment of the car concerning the 2nd example of this invention. In drawing 6 , the right wheel speed sensor which detects the wheel speed whose 21 is a rotational frequency per predetermined time of a right wheel, the left wheel speed sensor by which 22 detects the wheel speed of a left wheel, and 23 are the steering angle sensors as a steering angle detection means to detect the steering angle of the front wheel which is a steering wheel. The wheel speed Wr detected by both the above-mentioned wheel speed sensors 21 and 22, and Wl It is the rotation difference Rv of a right-and-left ring by subtracting mutually in a summation point 24. A rotation difference detection means 25 by which it is computed and the wheel speed sensors 21 and 22 and a summation point 24 detect the rotation difference of a right-and-left ring is constituted. The above-mentioned rotation difference Rv It is inputted into the approximation yaw rate value operation part 28 through a filter 26 and the normalization processing section 27. Moreover, steering angle Fs detected by the

above-mentioned steering angle sensor 23 It is inputted into the approximation yaw rate value operation part 28 through the normalization processing section 27.

[0044] The above-mentioned approximation yaw rate value operation part 28 is approximation yaw rate value phip by the neural network operation to which it is constituted by the neural network who makes an input variable the rotation difference normalizing value Rvn and the steering angle normalizing value Fsn of a right-and-left ring which were respectively normalized in the normalization processing section 27, and has the neurone of plurality (they are six pieces.in the case of this example) in an interlayer, and this neural network considers the rotation difference normalizing value Rvn and the steering angle normalizing value Fsn of a right-and-left ring as an input variable. It computes. This approximation yaw rate value phip It is inputted into the presumed yaw rate value operation part 30.

[0045] Moreover, the wheel speed Wr detected by both the above-mentioned wheel speed sensors 21 and 22 and Wl While being mutually added in a summation point 31, a vehicle speed detection means 33 by which the vehicle speed V is computed and the wheel speed sensors 21 and 22, a summation point 31, and the multiplier addition section 32 detect the vehicle speed V is constituted by doubling this aggregate value 1/2 in the multiplier addition section 32. The vehicle speed V is inputted into the 1st correction factor operation part 34. This 1st correction factor operation part 34 is the correction factor [ map / which is shown in drawing 7 / which was set up beforehand ] K1 according to the vehicle speed V. It sets. With the above-mentioned map, it is a correction factor K1. At the time of the low vehicle speed (for example, V<30 km/h), at the time of 1.0 and the high vehicle speed (for example, V>100 km/h), in 0.5 and an inside vehicle speed field (for example, 30 km/h<=V<=100 km/h), it is set up so that it may become small linearly, as the vehicle speed becomes large between 1.0-0.5. Correction factor K1 called for by the above-mentioned 1st correction factor operation part 34 It is inputted into the presumed yaw rate value operation part 30.

[0046] Furthermore, an acceleration detection means 37 by which the car-body acceleration g is computed and a summation point 35 and a delay circuit 36 detect the car-body acceleration g by being inputted after 1 measurement timing ****** in a delay circuit 36, and subtracting both this input value mutually in this summation point 35 in addition to the above-mentioned vehicle speed detection means 33 while the above-mentioned vehicle speed V is inputted as it is to a summation point 35 is constituted. The car-body acceleration g is inputted into the 2nd correction factor operation part 38. This 2nd correction factor operation part 38 is the correction factor [ map / which is shown in drawing 8 / which was set up beforehand ] K2 according to the car-body acceleration g. It sets. With the above-mentioned map, it is a correction factor K2. At the time of low acceleration (for example, g<2 km/h/sec), at the time of 1.0 and high acceleration (for example, g>6 km/h/sec), in 0.8 and an inside acceleration field (for example, 2 km/h/sec <=V<=6 km/h/sec), it is set up so that it may become small linearly, as car-body acceleration becomes large between 1.0-0.8. Correction factor K2 called for by the above-mentioned 2nd correction factor operation part 38 It is inputted into the presumed yaw rate value operation part 30.

[0047] The above-mentioned presumed yaw rate value operation part 10 is approximation yaw rate value phip. A correction factor K1 and K2 The presumed yaw rate value phi (=phip, K1, and K2) is computed by multiplying, respectively. This presumed yaw rate value phi is the output signal of yaw rate presumption equipment.

[0048] Next, in the yaw rate presumption equipment of the 2nd example of the above, the yaw rate presumption approach which is the operations sequence in the case of presuming a yaw rate is explained according to the flow chart shown in drawing 9 .
[0049] It is the right wheel speed Wr as car movement information at the step S52 after waiting to become measurement timing at step S51 first in drawing 9 . And left wheel speed Wl While measuring by the wheel speed sensors 21 and 22, respectively, it is the steering angle Fs as driver actuation information at step S53. It measures by the steering angle sensor 23. Then, it sets to step S54 and is the above-mentioned right wheel speed Wr. Left wheel speed Wl While searching for the right-and-left ring rotation difference Rv which is difference in a summation point 24, it is this right-and-left ring rotation difference Rv. It receives and filter count is carried out with a filter 26. This right-and-left ring rotation difference Rv Formula ** which was described in the case of the 1st example performs filter count.
[0050] Right-and-left ring rotation difference Rv which is the input in the normalization processing section 27 in after an appropriate time and step S55 And steering angle Fs It normalizes. Formula ** which was described in the case of the 1st example performs this normalization count. Then, the neural network operation which makes an input variable the right-and-left ring rotation difference normalizing value Rvn and the steering angle normalizing value Fsn by the approximation yaw rate value operation part 28 at step S56 is carried out, and it is approximation yaw rate value phip. It computes. This approximation yaw rate value phip Count is performed according to the flow chart shown in drawing 3 which was described in the case of the 1st example.
[0051] Then, they are the wheel speed Wr of a right-and-left ring, and Wl with the vehicle speed detection means 33 at step S57. While computing the vehicle speed V (=(Wr+Wl)/2) by being based, the differential value empty vehicle object acceleration g of this vehicle speed V (=V (t)-V (t-1)) is computed with the acceleration detection means 37 by step S58. Next, correction factor [ step / S59 ] K1 according to the above-mentioned vehicle speed V in the 1st correction factor operation part 34 Correction factor [ step / S60 ] K2 according to the above-mentioned car-body acceleration g in the 2nd correction factor operation part 38 while computing It computes. And it is approximation yaw rate value phip at step S61. Both the above-mentioned correction factors K1 and K2 The presumed yaw rate value phi (=phip, K1, and K2) is computed by multiplying, respectively. After an appropriate time, the presumed yaw rate value phi is outputted at step S62, and it returns to step S51.
[0052] As mentioned above, it is approximation yaw rate value phip by the neural network operation which makes an input variable the right-and-left ring rotation difference normalizing value Rvn with a large related degree and the steering angle normalizing value Fsn with a yaw rate in the 2nd example. While computing The vehicle speed V and the correction factor K1 respectively corresponding to acceleration g, and K2 It asks and is this correction factor K1 and K2. Above-mentioned approximation yaw rate value phip Since the presumed yaw rate value phi is computed by multiplying, The above-mentioned right-and-left ring rotation difference normalizing value Rvn, the steering angle normalizing value Fsn, and vehicle speed normalizing value Vn Car-body acceleration normalizing value gn It compares, when computing the presumed yaw rate value phi by the neural network operation made into an input variable. An interlayer's number of neurone combined with the degree of input and these in a neural network can be lessened. Consequently, time amount which the whole neural network operation takes

can be lessened, and the burden of the computer which performs this operation can be mitigated. Moreover, since the degree of input itself does not decrease, presumed precision of a yaw rate can be made good.

[0053] Here, it is a correction factor K1 and K2 as the above-mentioned vehicle speed V and the car-body acceleration g become large. It is made small and, thereby, is approximation yaw rate value phip about the presumed yaw rate value phi. The vehicle speed V or the car-body acceleration g follows on becoming large, a wheel becomes easy to slip, and it is because it is hard coming to generate a yaw rate to compare and to set up small.

[0054] Drawing 10 is the block diagram of the yaw rate presumption equipment of the car concerning the 3rd example of this invention. In drawing 10 , the right wheel speed sensor which detects the wheel speed whose 41 is a rotational frequency per predetermined time of a right wheel, the left wheel speed sensor by which 42 detects the wheel speed of a left wheel, and 43 are the steering angle sensors as a steering angle detection means to detect the steering angle of the front wheel which is a steering wheel. The wheel speed Wr detected by both the above-mentioned wheel speed sensors 41 and 42, and Wl It is the rotation difference Rv of a right-and-left ring by subtracting mutually in a summation point 44. A rotation difference detection means 45 by which it is computed and the wheel speed sensors 41 and 42 and a summation point 44 detect the rotation difference of a right-and-left ring is constituted. The above-mentioned rotation difference Rv It is inputted into the approximation yaw rate value operation part 48 through a filter 46. This approximation yaw rate value operation part 48 is the rotation difference Rv. The following linearity type phi1 =Rv/d led to the radical from the geometric relation at the time of circle revolution -- It is the approximation yaw rate value phi 1 by **. It computes. However, d is a tread.

[0055] Moreover, the wheel speed Wr detected by both the above-mentioned wheel speed sensors 41 and 42 and Wl While being mutually added in a summation point 51, a vehicle speed detection means 53 by which the vehicle speed V is computed and the wheel speed sensors 41 and 42, a summation point 51, and the multiplier addition section 52 detect the vehicle speed V is constituted by doubling this aggregate value 1/2 in the multiplier addition section 52. The vehicle speed V is inputted into the error value operation part 55 through the normalization processing section 54.

[0056] Steering angle Fs detected by the above-mentioned steering angle sensor 43 on the other hand It is inputted into the error value operation part 55 through the normalization processing section 54. Moreover, steering angle Fs While being inputted as it is to a summation point 56, it is inputted after 1 measurement timing ****** in a delay circuit 57, and a steering speed detection means 58 by which the steering rate Dfs is computed and the steering angle sensor 43, a summation point 56, and a delay circuit 57 detect the steering rate Dfs is constituted by subtracting both this input value mutually in this summation point 56. The steering rate Dfs is also inputted into the error value operation part 55 through the normalization processing section 54.

[0057] The above-mentioned error value operation part 55 is the vehicle speed normalizing value Vn respectively normalized in the normalization processing section 54. The steering angle normalizing value Fsn and steering rate normalizing value Dfsn It is constituted by the neural network who considers as an input variable and has the neurone of plurality (they are six pieces in the case of this example) in an interlayer, and this neural network is the vehicle speed normalizing value Vn. The steering angle normalizing

value Fsn and steering rate normalizing value Dfsn The error value er is computed by the neural network operation made into an input variable. Approximation yaw rate value phip computed by this error value er and the above-mentioned approximation yaw rate value operation part 48 By being mutually added in a summation point 59, the presumed yaw rate value phi is computed and, therefore, the above-mentioned summation point 59 has a function as presumed yaw rate value operation part which computes the presumed yaw rate value phi. The above-mentioned presumed yaw rate value phi is the output signal of yaw rate presumption equipment.

[0058] Next, in the yaw rate presumption equipment of the 3rd example of the above, the yaw rate presumption approach which is the operations sequence in the case of presuming a yaw rate is explained according to the flow chart shown in drawing 11 .

[0059] It is the right wheel speed Wr as car movement information at the step S72 after waiting to become measurement timing at step S71 first in drawing 11 . And left wheel speed Wl While measuring by the wheel speed sensors 41 and 42, respectively, it is the steering angle Fs as driver actuation information at step S73. It measures by the steering angle sensor 43. Then, it sets to step S74 and is the above-mentioned right wheel speed Wr. Left wheel speed Wl Right-and-left ring rotation difference Rv which is difference While asking in a summation point 44, it is this right-and-left ring rotation difference Rv. It receives and filter count is carried out with a filter 46. This right-and-left ring rotation difference Rv Formula ** which was described in the case of the 1st example performs filter count.

[0060] The vehicle speed V which is the input in the normalization processing section 54 in after an appropriate time and step S75, and steering angle Fs And the steering rate Dfs is normalized. This normalization is preceded and they are the wheel speed Wr of a right-and-left ring, and Wl with the vehicle speed detection means 53. While computing the vehicle speed V by being based, it is the steering angle Fs with the steering speed detection means 58. The steering rate Dfs which is a differential value is computed. Normalization count is the following formula. Vn = (V-70)/70 Fsn=Fs/5 Dfsn = (Fs (t)-Fs)/(t-1) 20 P=[Vn, Fsn, Dfsn] t --** performs.

[0061] Then, it is the vehicle speed normalizing value Vn at the error value operation part 55 in step S76. The steering angle normalizing value Fsn and steering rate normalizing value Dfsn The error value er is computed by carrying out the neural network operation made into an input variable. Count (count of a correction term neural network) of this error value er is performed according to the flow chart shown in drawing 12 .

[0062] Then, it is the right-and-left ring rotation difference Rv at the approximation yaw rate value operation part 48 in step S77. Approximation yaw rate value phip (= Rvf/d) is computed by the linearity formula led to the radical from the geometric relation at the time of circle revolution, and it is this approximation yaw rate value phip at a summation point 59 in step S78. The presumed yaw rate value phi (=phip+er) is computed by adding the above-mentioned error value er. After an appropriate time, the presumed yaw rate value phi is outputted at step S79, and it returns to step S71.

[0063] Next, count of a correction term neural network is explained according to the flow chart shown in drawing 12 .

[0064] After first inputting the normalization information P (the vehicle speed normalizing value Vn, the steering angle normalizing value Fsn, and the steering rate normalizing value Dfsn) at step S81 in drawing 12 , It is the matrix product U0 of this normalization information P and the interlayer weighting factor W1 (i, j) at step S82. It

asks and is this matrix U0 at step S83. Interlayer bias coefficient B 1 (i) is added and it is newly a matrix U0 about that value. It replaces. Here, i is an interlayer's number of neurone, j is the number of inputs, and, in the case of this example, it is i= 6 and j= 3.
[0065] Then, it is the above-mentioned matrix U0 at step S84. The interlayer transfer function U (=tanh (U0)) which is a tangent hyperbolic function is calculated. Count of the middle class transfer function U is performed according to the flow chart shown in drawing 5 which was described in the case of the 1st example. They are the above-mentioned interlayer transfer function U and the output layer weighting factor W2 at after an appropriate time and step S85. The error value er which is a matrix product with (i) is calculated, and it is output layer bias multiplier B-2 to this error value er at step S86. It adds and that value is newly replaced with the error value er. It returns to the flow chart of drawing 11 after that.
[0066] In addition, the middle class weighting factor W1, the middle class bias coefficient B 1, and the output layer weighting factor W2 And output layer bias multiplier B-2 It is determined [ all / equipment ] before manufacture of the yaw rate presumption equipment concerning this example by the study using a back-propagation method.
[0067] As mentioned above, it sets in the 3rd example and is the rotation difference Rv of a right-and-left ring. It is approximation yaw rate value phip at the linearity type led to the radical from the geometric relation at the time of circle revolution. While computing Vehicle speed normalizing value Vn The steering angle normalizing value Fsn and steering rate normalizing value Dfsn The error value er is computed by the neural network operation made into an input variable. It is above-mentioned approximation yaw rate value phip about this error value er. Since the presumed yaw rate value phi is computed by adding, The above-mentioned vehicle speed normalizing value Vn, the steering angle normalizing value Fsn, and steering rate normalizing value Dfsn It compares, when computing the presumed yaw rate value phi by the neural network operation which, in addition, also makes an input variable a right-and-left ring rotation difference normalizing value. An interlayer's number of neurone combined with the degree of input and these in a neural network can be lessened. Consequently, time amount which the whole neural network operation takes can be lessened, and the burden of the computer which performs this operation can be mitigated. Moreover, approximation yaw rate value phip computed by the linearity formula drawn from the geometric relation at the time of circle revolution The presumed precision of a yaw rate can be raised by adding and amending the error value er by the neural network operation.
[0068] Drawing 13 is the block diagram of the yaw rate presumption equipment of the car concerning the 4th example of this invention. Although the yaw rate presumption equipment of this 4th example is the same as it of the 3rd example fundamentally, the configuration which amends the presumed yaw rate value phi according to the car-body acceleration g is added.
[0069] Namely, presumed yaw rate value phip computed in the summation point 59 as presumed yaw rate value operation part It is inputted into the presumed yaw rate value amendment section 60. On the other hand, the vehicle speed V computed with the vehicle speed detection means 53 (multiplier addition section 52) While being inputted as it is to a summation point 61, it is inputted after 1 measurement timing ****** in a delay circuit 62. An acceleration detection means 63 by which the car-body acceleration g is computed and the vehicle speed detection means 53, a summation point 61, and a delay circuit 62 detect the car-body acceleration g is constituted by subtracting both this input value

mutually in this summation point 61. The car-body acceleration g is inputted into the correction factor operation part 64.
[0070] The above-mentioned correction factor operation part 64 defines the correction factor K according to the car-body acceleration g on the map which is shown in drawing 14 and which was set up beforehand. the above-mentioned map -- at the time of low acceleration (for example, g<2 km/h/sec), as for a correction factor K, car-body acceleration becomes large between 1.0-0.8 in 0.8 and an inside acceleration field (for example, 2 km/h/sec<=V<=6 km/h/sec) at the time of 1.0 and high acceleration (for example, g>6 km/h/sec) -- it is set up so that it is alike, and may follow and may become small linearly. The correction factor K called for by the correction factor operation part 64 is inputted into the presumed yaw rate value amendment section 60. This presumed yaw rate value amendment section 60 multiplies the presumed yaw rate value phi by the correction factor K, and performs amendment which newly transposes the product to the presumed yaw rate value phi. The presumed yaw rate value phi after this amendment is the output signal of yaw rate presumption equipment.
[0071] Next, in the yaw rate presumption equipment of the 4th example of the above, the yaw rate presumption approach which is the operations sequence in the case of presuming a yaw rate is explained according to the flow chart shown in drawing 15 .
[0072] It is the right wheel speed Wr as car movement information at the step S92 after waiting to become measurement timing at step S91 first in drawing 15 . And left wheel speed Wl While measuring, it is the steering angle Fs as driver actuation information at step S93. It measures. Then, it is the right-and-left ring rotation difference Rv at step S94. While asking, after carrying out filter count, input (the vehicle speed V, the steering angle Fs, and steering rate Dfs) is normalized at step S95, and it is the vehicle speed normalizing value Vn at step S96. The steering angle normalizing value Fsn and steering rate normalizing value Dfsn The error value er is computed by carrying out the neural network operation made into an input variable. Then, it is the right-and-left ring rotation difference Rv at step S97. It is approximation yaw rate value phip at the linearity type led to the radical from the geometric relation at the time of circle revolution. It computes and is this approximation yaw rate value phip at step S98. The presumed yaw rate value phi is computed by adding the above-mentioned error value er. The above steps S91-S98 are the same as steps S71-S78 of the flow chart shown in drawing 11 which was described in the case of the 3rd example.
[0073] The differential value empty vehicle object acceleration g of the vehicle speed V (=V (t)-V (t-1)) is computed with the acceleration detection means 63 by step S99 after an appropriate time, and it is step S100. It asks for the correction factor K according to the above-mentioned car-body acceleration g by the correction factor operation part 64. Then, step S101 The above-mentioned presumed yaw rate value phi is multiplied by the correction factor K in the presumed yaw rate amendment section 60, amendment which newly transposes that product to the presumed yaw rate value phi (= phi-K) is performed, and it is SUTEPPUTO 102. The presumed yaw rate value phi after this amendment is outputted, and it returns to step S91.
[0074] It sets in the 4th above example and is the rotation difference Rv of a right-and-left ring. It is approximation yaw rate value phip at the linearity type led to the radical from the geometric relation at the time of circle revolution. While computing Vehicle speed normalizing value Vn The steering angle normalizing value Fsn and steering rate normalizing value Dfsn The error value er is computed by the neural network operation

made into an input variable. It is above-mentioned approximation yaw rate value phip about this error value er. The presumed yaw rate value phi is computed by adding. Furthermore, since it asked for the correction factor K corresponding to the car-body acceleration g, it multiplied by this correction factor K with the above-mentioned presumed yaw rate value phi and the presumed yaw rate value phi is amended, as compared with the case of the 3rd example, the presumed precision of a yaw rate can be raised more. Here, the car-body acceleration g follows on becoming large, a wheel becomes easy to slip, and it is because it is hard coming to generate a yaw rate to amend so that a correction factor K may be made small as the car-body acceleration g becomes large, and the presumed yaw rate value phi may be made small.

[0075] In addition, this invention is not limited to the above 1st - the 4th example, and includes various modifications. For example, at each above-mentioned example, it is the rotation difference Rv and the steering angle Fs of a right-and-left ring. Although the yaw rate was presumed using the vehicle speed V, the car-body acceleration g, or the steering rate Dfs as a car quantity of state of an except, you may make it this invention presume a yaw rate using other car quantity of states, such as coefficient of friction of the road surface relevant to a yaw rate.

[0076] Moreover, in the 3rd and 4th examples of the above, it is the rotation difference Rv of a right-and-left ring at the approximation yaw rate value operation part 48. It is approximation yaw rate value phip at the linearity type led to the radical from the geometric relation at the time of circle revolution. It computes. Although the error value was computed by the neural network operation which makes an input variable the steering angle Fs (in detail steering angle normalizing value Fsn) and other car quantity of states (they are the vehicle speed V and the steering rate Dfs at an example) by the error value operation part 55 Invention according to claim 5, 6, or 9 is the steering angle Fs at the approximation yaw rate value operation part 48. It is approximation yaw rate value phip at the linearity type led to the radical from the geometric relation at the time of circle revolution. It computes. It is the rotation difference Rv of a right-and-left ring at the error value operation part 55. You may make it compute an error value by the neural network operation which makes other car quantity of states an input variable. In this case, approximation yaw rate value phip Linearity type phip ={V/(1+axV2)} xFs/L -- It is **. However, L is a wheel base and a is a stability factor.

[0077]

[Effect of the Invention] According to invention according to claim 1, 2, or 7, like the above, an approximation yaw rate value is computed by the neural network operation which makes an input variable the rotation difference and steering angle of a right-and-left ring. By computing a presumed yaw rate value by the neural network operation which makes an input variable this approximation yaw rate value and other car quantity of states, such as the vehicle speed and car-body acceleration Time amount which lessens the degree of each neural network's input and an interlayer's number of neurone with slight height, and a neural network operation takes the presumed precision of a yaw rate can be lessened, and the burden of a computer can be mitigated.

[0078] While a related degree with a yaw rate computes an approximation yaw rate value by the neural network operation which makes an input variable the rotation difference and steering angle of a large right-and-left ring according to invention according to claim 3, 4, or 8 By computing a presumed yaw rate value by calculating the correction factor which is the function value from other car quantity of states, such as the vehicle speed and car-

body acceleration, and multiplying by this correction factor with the above-mentioned approximation yaw rate value Time amount which lessens the degree of a neural network's input and an interlayer's number of neurone with slight height, and a neural network operation takes the presumed precision of a yaw rate can be lessened, and the burden of a computer can be mitigated.

[0079] While computing an approximation yaw rate value by the linearity formula drawn from the geometric relation at the time of circle revolution based on either the rotation difference of a right-and-left ring, and the steering angle according to invention according to claim 5 or 9 By computing an error value by the neural network operation which makes an input variable another side and other car quantity of states, such as the vehicle speed and car-body acceleration, and computing a presumed yaw rate value by adding this error value to the above-mentioned approximation yaw rate value Time amount which lessens the degree of a neural network's input and an interlayer's number of neurone with slight height, and a neural network operation takes the presumed precision of a yaw rate can be lessened, and the burden of a computer can be mitigated.

[0080] While computing an approximation yaw rate value by the linearity formula drawn from the geometric relation at the time of circle revolution based on the rotation difference of a right-and-left ring according to invention according to claim 6 An error value is computed by the neural network operation which makes an input variable a steering angle, a steering rate, and the vehicle speed. By computing a presumed yaw rate value by adding this error value to the above-mentioned approximation yaw rate value, asking for the correction factor which is the function value from car-body acceleration further, multiplying by this correction factor with the above-mentioned presumed yaw rate value, and amending a presumed yaw rate value The presumed precision of a yaw rate can be raised rather than the case of invention according to claim 5.

[Translation done.]